U.S. Department
of Transportation

Federal Aviation Administration

Memorandum

Subject: **INFORMATION**: Final Policy Statement; Diesel Engine Installation; PS-ACE100-2002-004

Date: May 15, 2003

From: Manager, Small Airplane Directorate, ACE-100

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To: SEE DISTRIBUTION

I. Summary

The purpose of this policy statement is to help identify appropriate certification requirements for installation of a diesel engine into a small airplane. It includes guidance related to methods of compliance as well as potential equivalent level of safety findings (ELOS) and special conditions.

Installation of diesel engines into part 23 airplanes may include design features not envisioned when 14 CFR part 23 was created. This policy highlights areas where special conditions may be appropriate for these installations. However, appropriate special conditions for each installation must be determined on a case-by-case basis in accordance with 14 CFR part 21, §§ 21.16, 21.17 and 14 CFR part 11.

The installation of a diesel engine in a small certificated airplane design is not considered a design change so substantial that it would require a new airplane Type Certificate (TC) under 14 CFR part 21, § 21.19. Therefore, it is considered appropriate to install a certificated diesel engine into a certificated airplane using the Supplemental Type Certificate (STC) or Amended Type Certificate (ATC) process.

All proposed diesel engine installations, whether supplemental, amended or new TC projects, will be considered significant as defined in Order 8100.5. Given the significance of the change, early program coordination between the Standards Office and the Aircraft Certification Office (ACO) is necessary. The ACO is expected to notify the Standards Office of such projects promptly and forward certification project notifications and associated certification plans as soon as practical after project application. The ACO will identify the technological areas of concern identified in this policy statement as well as any additional concerns and develop a G-1 issue paper to establish the certification basis.

II. Discussion of Significant Issues

General

Engines are being proposed to be certificated for installation in aircraft, especially small airplanes and airships, that operate on compression ignition power cycles rather than spark ignition power cycles. Some aircraft diesel engines have been type certificated with others expected in the near future. Diesel engines, however, have not been utilized in type certificated airplanes in the United States for over 70 years. While some historical experience may be useful, there are many new and novel issues to be addressed as modern diesel engine technology is integrated into modern aircraft.

Nomenclature

In 14 CFR part 23, the utilization of fuel requirements is often used as a proxy for engine type (reciprocating versus turbine; AvGas versus Jet A, respectively). The phrase “reciprocating engine” is often shorthand for “operates on AvGas” and the phrase “turbine engine” is often shorthand for “operates on kerosene-based fuels.” To date, this approach has been sufficient. However, an aircraft diesel engine is typically a reciprocating engine that would operate on jet fuel, and it was not envisioned by the 14 CFR part 23 rules. While this policy has been developed to address most of the known technical issues where diesel engine and gasoline engine requirements must be differentiated, there may be other assumptions built into the regulations that will need to be evaluated to determine the appropriate technical requirements.

For the purposes of this policy statement, the term "conventional reciprocating engine" will be used to describe spark ignition, reciprocating engines that run on AvGas. For the purposes of this policy statement, the term "aircraft diesel engine," or "ADE," will be used to describe compression ignition, reciprocating engines that run on kerosene-based fuels.

Installation Manual

Title 14 CFR part 33, § 33.5, requires, as part of the engine type certification effort, that an instruction manual for installation and operation of the engine be prepared and approved prior to issuance of the engine TC. 14 CFR part 23, § 23.901, requires that engine installations comply with these instructions. The applicable regulations identified in this policy statement (including potential special conditions), combined with the engine installation instructions, should provide a comprehensive list of installation requirements for most diesel engine installations. In addition, the methods of compliance and potential ELOS's described in this policy statement should assist applicants and ACO engineers when assessing methods to demonstrate compliance to applicable regulations.

Fuels

The FAA's current understanding is that Jet A is the leading candidate for use in aircraft diesel engines; however, this does not rule out other fuels such as #2 Diesel or some other alternative fuel (bio-diesel). The engine Type Certificate Data Sheet (TCDS) identifies the approved fuel(s) for use in an aircraft diesel engine. Any fuels to be used in aircraft diesel engines will need a specification and Type Certificate Data Sheet (TCDS) approval.

The fuel and additives required for the aircraft diesel engine will be determined as part of the 14 CFR part 33 certification process and will be specified on the engine TCDS and in the engine installation data. For a small airplane powered with a reciprocating engine that operates on kerosene-based fuels, such as an aircraft diesel engine, certain "turbine engine" fuel-related requirements should be met in lieu of the gasoline fuel related requirements. Additives needed for turbine fuels that will also be required by an aircraft diesel engine (such as anti-icing and biocide additives) will be called out on the engine TCDS and in the fuel specification listed in the TCDS.

The appropriate fuels and additives, consistent with both the engine certification and airframe certification, must also be specified on the aircraft TCDS. However, when approaching an aircraft diesel engine installation project, certain aspects of the diesel engine and its certificated fuel requirements should be kept in mind. For instance, the cetane number is the primary parameter that defines diesel engine fuel that is similar to octane rating for conventional reciprocating engines. Using the appropriate cetane rated fuel in a diesel engine is critical to developing the appropriate power. Commercial turbine fuels will probably not be given a cetane rating; therefore, aircraft diesel engines will be approved and certificated to operate on a specific turbine fuel(s). Any additional limiting parameters or specifications for the fuel will need to be defined on the engine TCDS, in lieu of specifying cetane requirements.

If automotive diesel fuel is to be approved, appropriate specifications will need to be identified. Approval of fuels that do not have a specification (such as protein or plant-based (biodiesel) fuels) is anticipated; these will be handled on a case-by-case basis as approval is requested. While the engine certification process addresses these concerns, it is best to be aware of the possible complications of specifying appropriate fuels for an aircraft diesel engine and the associated airframe compatibility issues. Compatibility of the fuel system materials (elastomers, sealants, seals, liners, hoses, composite parts, etc.) with the approved fuels for an aircraft diesel engine has to be established.

Engine Controls

Many new technology aircraft diesel engines utilize a Full Authority Digital Engine Control (FADEC) or Electronic Engine Control (EEC). Such systems are not unique to aircraft diesel engines and are increasingly common on

conventional reciprocating engines. Previous aircraft FADEC installations have required a special condition addressing § 23.1309 -- Equipment, Systems and Installation. This special condition is available from the Small Airplane Directorate Standards Office. In addition, an appropriate airplane level analysis must be performed to determine appropriate levels of High Intensity Radiated Fields (HIRF) compliance, and the HIRF special condition will most likely be applied. The software certification level will need to be compliant with the appropriate RTCA DO178 level as described in AC 23.1309-1C.

This policy statement briefly touches on the subject of FADEC installation; however, it is not intended to cover all of the aspects of FADEC installation. A future policy statement covering FADEC installation into 14 CFR part 23 aircraft is currently being written.

Vibration

Aircraft diesel engines may yield a greater level of vibration than current aircraft propulsion systems. This issue is based upon feedback from industry during the development of aircraft diesel engines. As part of the basic compliance efforts for an aircraft diesel engine airplane, the effects of vibration levels higher than those typical for conventional reciprocating engine powered airplanes must be considered. In addition, the one cylinder inoperative condition will need to be evaluated. The primary concern is that the vibratory loads imparted to the airframe by an aircraft diesel engine may be in excess of the experience of the general aviation fleet, thereby reducing the margin of design safety. The goal of this policy statement is to ensure that the aircraft fleet will have an equivalent or better level of safety without unnecessary regulatory requirements.

Regulatory Review

The following table is taken from 14 CFR part 23 with an emphasis on the sections that require more consideration when incorporating a diesel engine for aircraft use. The following is the criteria for a special condition as defined in § 21.16:

"If the Administrator finds that the airworthiness regulations of this subchapter do not contain adequate or appropriate safety standards for an aircraft, aircraft engine, or propeller because of a novel or unusual design feature of the aircraft, aircraft engine or propeller, he prescribes special conditions and amendments thereto for the product. The special conditions are issued in accordance with Part 11 of this chapter and contain such safety standards for the aircraft, aircraft engine or propeller as the Administrator finds necessary to establish a level of safety equivalent to that established in the regulations."

The policy statement makes several references to special conditions due to the new and novel features of aircraft diesel engines. The existing regulations lack

the adequate or appropriate safety standards equivalent to those currently utilized by aircraft propulsion systems. There are 14 potential special conditions identified in the regulations matrix that starts on the next page. The sections annotated with an asterisk (*) highlight requirements that may be applicable via special condition or may have additional requirements applied via special condition. See the appropriate text paragraph describing the potential criteria for the special condition.

PART 21 AND 23 – AIRWORTHINESS STANDARDS: NORMAL, UTILITY, ACROBATIC, AND COMMUTER CATEGORY AIRPLANES: AFFECTED REGULATIONS			
SECTION	TITLE	APPLICABILITY	ANTICIPATED DIFFERENCES AND RATIONALE
21.19	ISSUE OF TYPE CERTIFICATE: NORMAL, UTILITY, ACROBATIC, COMMUTER, AND TRANSPORT CATEGORY AIRCRAFT; MANNED FREE BALLOONS; SPECIAL CLASSES OF AIRCRAFT; AIRCRAFT ENGINES; PROPELLERS	YES	NONE
21.21*	CERTIFICATION PROCEDURES FOR PRODUCTS AND PARTS	YES	SEE COMMENTS REGARDING UNSAFE CONDITIONS. SPECIAL CONDITION(S) MAY APPLY – SEE PARAGRAPH TEXT.
23.1	APPLICABILITY.	YES	NONE
23.2	SPECIAL RETROACTIVE REQUIREMENTS.	YES	NONE
23.3	AIRPLANE CATEGORIES.	YES	NONE
SUBPART B – FLIGHT			
GENERAL			
23.21	PROOF OF COMPLIANCE.	YES	NONE
23.23	LOAD DISTRIBUTION LIMITS.	YES	NONE
23.25	WEIGHT LIMITS.	YES	NONE
23.29	EMPTY WEIGHT AND CORRESPONDING CENTER OF GRAVITY	YES	NONE
23.31	REMOVABLE BALLAST.	YES	NONE
23.33	PROPELLER SPEED AND PITCH LIMITS	YES	NONE
PERFORMANCE			
23.45	GENERAL.	YES	NONE
23.49	STALLING PERIOD.	YES	NONE
23.51	TAKEOFF SPEEDS.	YES	NONE
23.53	TAKEOFF PERFORMANCE.	YES	NONE
23.55	ACCELERATE-STOP DISTANCE.	YES	NONE
23.57	TAKEOFF PATH.	YES	NONE
23.59	TAKEOFF DISTANCE AND TAKEOFF RUN	YES	NONE
23.61	TAKEOFF FLIGHT PATH.	YES	NONE
23.63	CLIMB: GENERAL.	YES	NONE
23.65	CLIMB: ALL ENGINES OPERATING	YES	NONE
23.66	TAKEOFF CLIMB: ONE-ENGINE	YES	NONE
23.67	CLIMB: ONE ENGINE INOPERATIVE	YES	NONE
23.69	ENROUTE CLIMB/DESCENT.	YES	NONE
23.71	GLIDE: SINGLE-ENGINE AIRPLANES.	YES	SEE COMMENT CONCERNING GLIDE CHARACTERISTICS IN SUBPART B GENERAL DISCUSSION.
23.73	REFERENCE LANDING APPROACH SPEED	YES	NONE
23.75	LANDING DISTANCE.	YES	NONE
23.77	BALKED LANDING.	YES	NONE
FLIGHT CHARACTERISTICS			
23.141	GENERAL.		
CONTROLLABILITY AND MANEUVERABILITY			
23.143	GENERAL.	YES	NONE
23.145	LONGITUDINAL CONTROL.	YES	NONE
23.147	DIRECTIONAL AND LATERAL CONTROL	YES	NONE

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SECTION	TITLE	APPLICABILITY	ANTICIPATED DIFFERENCES AND RATIONALE
23.149	MINIMUM CONTROL SPEED.	YES	NONE
23.151	ACROBATIC MANEUVERS.	YES	NONE
23.153	CONTROL DURING LANDINGS.	YES	NONE
23.155	ELEVATOR CONTROL FORCE IN MANEUVERS	YES	NONE
23.157	RATE OF ROLL.	YES	NONE
TRIM			
23.161	TRIM.	YES	NONE
STABILITY			
23.171	GENERAL.	YES	NONE
23.173	STATIC LONGITUDINAL STABILITY.	YES	NONE
23.175	DEMONSTRATION OF STATIC LONGITUDINAL STABILITY	YES	NONE
23.177	STATIC DIRECTIONAL AND LATERAL STABILITY	YES	NONE
23.181	DYNAMIC STABILITY.	YES	NONE
STALLS			
23.201	WINGS LEVEL STALL.	YES	NONE
23.203	TURNING FLIGHT AND ACCELERATED TURNING STALLS	YES	NONE
23.207	STALL WARNING.	YES	NONE
SPINNING			
23.221	SPINNING.	YES	NONE
GROUND AND WATER HANDLING CHARACTERISTICS			
23.231	LONGITUDINAL STABILITY AND CONTROL	YES	NONE
23.233	DIRECTIONAL STABILITY AND CONTROL	YES	NONE
23.235	OPERATION ON UNPAVED SURFACES	YES	NONE
23.237	OPERATION ON WATER.	YES	NONE
23.239	SPRAY CHARACTERISTICS.	YES	NONE
MISCELLANEOUS FLIGHT REQUIREMENTS			
23.251	VIBRATION AND BUFFETING.	YES	SEE COMMENT CONCERNING VIBRATION CHARACTERISTICS
23.253	HIGH SPEED CHARACTERISTICS.		
SUBPART C – STRUCTURE			
GENERAL			
23.301	LOADS.	YES	NONE
23.302	CANARD OR TANDEM WING CONFIGURATION	YES	NONE
23.303	FACTOR OF SAFETY.	YES	NONE
23.305	STRENGTH AND DEFORMATION.	YES	NONE

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SECTION	TITLE	APPLICABILITY	ANTICIPATED DIFFERENCES AND RATIONALE
23.307	PROOF OF STRUCTURE.	YES	NONE
FLIGHT LOADS			
23.321	GENERAL.	YES	NONE
23.331	SYMMETRICAL FLIGHT CONDITIONS.	YES	NONE
23.333	FLIGHT ENVELOPE.	YES	NONE
23.335	DESIGN AIRSPEEDS.	YES	NONE
23.337	LIMIT MANEUVERING LOAD FACTORS	YES	NONE
23.341	GUST LOADS FACTORS.	YES	NONE
23.343	DESIGN FUEL LOADS.	YES	NONE
23.345	HIGH LIFT DEVICES.	YES	NONE
23.347	UNSYMMETRICAL FLIGHT CONDITIONS.	YES	NONE
23.349	ROLLING CONDITIONS.	YES	NONE
23.351	YAWING CONDITIONS.	YES	NONE
23.361*	ENGINE TORQUE.	YES	SEE COMMENT CONCERNING ENGINE TORQUE CHARACTERISTICS. NOTE SUDDEN STOPPAGE CASES SHOULD BE CONSIDERED. SPECIAL CONDITION(S) MAY APPLY – SEE PARAGRAPH TEXT.
23.363	SIDE LOAD ON ENGINE MOUNT	YES	NONE
23.365	PRESSURIZED CABIN LOADS.	YES	NONE
23.367	UNSYMMETRICAL LOADS DUE TO ENGINE FAILURE	YES	NONE
23.369	REAR LIFT TRUSS.	YES	NONE
23.371	GYROSCOPIC AND AERODYNAMIC LOADS	YES	NONE
23.373	SPEED CONTROL DEVICES.	YES	NONE
CONTROL SURFACE AND SYSTEM LOADS			
23.391	CONTROL SURFACE LOADS.	YES	NONE
23.393	LOADS PARALLEL TO HINGE LINE	YES	NONE
23.395	CONTROL SYSTEM LOADS.	YES	NONE
23.397	LIMIT CONTROL FORCES AND TORQUES	YES	NONE
23.399	DUAL CONTROL SYSTEM.	YES	NONE
23.405	SECONDARY CONTROL SYSTEM.	YES	NONE
23.407	TRIM TAB EFFECTS.	YES	NONE
23.409	TABS.	YES	NONE
23.415	GROUND GUST CONDITIONS.	YES	NONE
HORIZONTAL STABILIZING AND BALANCING SURFACES			
23.421	BALANCING LOADS.	YES	NONE
23.423	MANEUVERING LOADS.	YES	NONE
23.425	GUST LOADS.	YES	NONE
23.427	UNSYMMETRICAL LOADS.	YES	NONE
VERTICAL SURFACES			
23.441	MANEUVERING LOADS.	YES	NONE
23.443	GUST LOADS.	YES	NONE
23.445	OUTBOARD FINS OR WINGLETS	YES	NONE

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SECTION	TITLE	APPLICABILITY	ANTICIPATED DIFFERENCES AND RATIONALE
AILERONS AND SPECIAL DEVICES			
23.455	AILERONS.	YES	NONE
23.459	SPECIAL DEVICES.		
GROUND LOADS			
23.471	GENERAL.	YES	NONE
23.473	GROUND LOAD CONDITIONS AND ASSUMPTIONS	YES	NONE
23.477	LANDING GEAR ARRANGEMENT.	YES	NONE
23.479	LEVEL LANDING CONDITIONS.	YES	NONE
23.481	TAIL DOWN LANDING CONDITIONS	YES	NONE
23.483	ONE-WHEEL LANDING CONDITIONS.	YES	NONE
23.485	SIDE LOAD CONDITIONS.	YES	NONE
23.493	BRAKED ROLL CONDITIONS.	YES	NONE
23.497	SUPPLEMENTARY CONDITIONS FOR TAIL WHEELS	YES	NONE
23.499	SUPPLEMENTARY CONDITIONS FOR NOSE WHEELS	YES	NONE
23.505	SUPPLEMENTARY CONDITIONS FOR SKIPLANES	YES	NONE
23.507	JACKING LOADS.	YES	NONE
23.509	TOWING LOADS.	YES	NONE
23.511	GROUND LOAD; UNSYMMETRICAL LOADS ON MULTIPLE-WHEEL UNITS	YES	NONE
WATER LOADS			
23.521	WATER LOAD CONDITIONS.	YES	NONE
23.523	DESIGN WEIGHTS AND CENTER OF GRAVITY	YES	NONE
23.525	APPLICATION OF LOADS.	YES	NONE
23.527	HULL AND MAIN FLOAT LOAD FACTORS	YES	NONE
23.529	HULL AND MAIN FLOAT LANDING CONDITIONS	YES	NONE
23.531	HULL AND MAIN FLOAT TAKEOFF CONDITION	YES	NONE
23.533	HULL AND MAIN FLOAT BOTTOM PRESSURES	YES	NONE
23.535	AUXILIARY FLOAT LOADS.	YES	NONE
23.537	SEAWING LOADS.	YES	NONE
EMERGENCY LANDING CONDITIONS			
23.561	GENERAL.	YES	NONE
23.562	EMERGENCY LANDING DYNAMIC CONDITIONS	YES	NONE
FATIGUE EVALUATION			
23.571	METALLIC PRESSURIZED CABIN STRUCTURES	YES	NONE
23.572	METALLIC WING, EMPENNAGE, AND ASSOCIATED STRUCTURES	YES	SEE COMMENT CONCERNING VIBRATION CHARACTERISTICS
23.573	DAMAGE TOLERANCE AND FATIGUE EVALUATION OF STRUCTURE	YES	SEE COMMENT CONCERNING VIBRATION CHARACTERISTICS

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SECTION	TITLE	APPLICABILITY	ANTICIPATED DIFFERENCES AND RATIONALE
23.574	METALLIC DAMAGE TOLERANCE AND FATIGUE EVALUATION OF COMMUTER CATEGORY AIRPLANES	YES	SEE COMMENT CONCERNING VIBRATION CHARACTERISTICS
23.575	INSPECTIONS AND OTHER PROCEDURES	YES	NONE
SUBPART D – DESIGN AND CONSTRUCTION			
23.601	GENERAL.	YES	NONE
23.603	MATERIALS AND WORKMANSHIP.	YES	NONE
23.605	FABRICATION METHODS.	YES	NONE
23.607	FASTENERS.	YES	NONE
23.609	PROTECTION OF STRUCTURE.	YES	NONE
23.611	ACCESSIBILITY PROVISIONS.	YES	NONE
23.613	MATERIAL STRENGTH PROPERTIES AND DESIGN VALUES	YES	SEE COMMENT CONCERNING VIBRATION CHARACTERISTICS
23.619	SPECIAL FACTORS.	YES	NONE
23.621	CASTING FACTORS.	YES	NONE
23.623	BEARING FACTORS.	YES	NONE
23.625	FITTING FACTORS.	YES	NONE
23.627	FATIGUE STRENGTH.	YES	SEE COMMENT CONCERNING VIBRATION CHARACTERISTICS
23.629*	FLUTTER.	YES	SEE COMMENT CONCERNING VIBRATION CHARACTERISTICS. SPECIAL CONDITION(S) MAY APPLY – SEE PARAGRAPH TEXT.
WINGS			
23.641	PROOF OF STRENGTH.	YES	NONE
CONTROL SURFACES			
23.651	PROOF OF STRENGTH.	YES	NONE
23.655	INSTALLATION.	YES	NONE
23.657	HINGES.	YES	NONE
23.659	MASS BALANCE.	YES	NONE
CONTROL SYSTEMS			
23.671	GENERAL.	YES	NONE
23.672	STABILITY AUGMENTATION AND AUTOMATIC AND POWER-OPERATED SYSTEMS	YES	NONE
23.673	PRIMARY FLIGHT CONTROLS.	YES	NONE
23.675	STOPS.	YES	NONE
23.677	TRIM SYSTEMS.	YES	NONE
23.679	CONTROL SYSTEM LOCKS.	YES	NONE
23.681	LIMIT LOAD STATIC TESTS	YES	NONE
23.683	OPERATION TESTS.	YES	NONE
23.685	CONTROL SYSTEM DETAILS.	YES	NONE
23.687	SPRING DEVICES.	YES	NONE
23.689	CABLE SYSTEMS.	YES	NONE
23.691	ARTIFICIAL STALL BARRIER SYSTEM	YES	NONE
23.693	JOINTS.	YES	NONE
23.697	WING FLAP CONTROLS.	YES	NONE
23.699	WING FLAP POSITION INDICATOR	YES	NONE
23.701	FLAP INTERCONNECTION.	YES	NONE

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SECTION	TITLE	APPLICABILITY	ANTICIPATED DIFFERENCES AND RATIONALE
23.703	TAKEOFF WARNING SYSTEM.	YES	NONE
LANDING GEAR			
23.721	GENERAL.	YES	NONE
23.723	SHOCK ABSORPTION TESTS.	YES	NONE
23.725	LIMIT DROP TESTS.	YES	NONE
23.726	GROUND LOAD DYNAMIC TESTS	YES	NONE
23.727	RESERVE ENERGY ABSORPTION DROP TEST	YES	NONE
23.729	LANDING GEAR EXTENSION AND RESTRACTION SYSTEM	YES	NONE
23.731	WHEELS.	YES	NONE
23.733	TIRES.	YES	NONE
23.735	BRAKES.	YES	NONE
23.737	SKIS.	YES	NONE
23.745	NOSE/TAIL WHEEL STEERING.	YES	NONE
FLOATS AND HULLS			
23.751	MAIN FLOAT BUOYANCY.	YES	NONE
23.753	MAIN FLOAT DESIGN.	YES	NONE
23.755	HULLS.	YES	NONE
23.757	AUXILIARY FLOATS.	YES	NONE
PERSONNEL AND CARGO ACCOMMODATIONS			
23.771	PILOT COMPARTMENT.	YES	NONE
23.773	PILOT COMPARTMENT VIEW.	YES	NONE
23.775	WINDSHIELDS AND WINDOWS.	YES	NONE
23.777	COCKPIT CONTROLS.	YES	SEE COMMENT CONCERNING SINGLE CONTROL LEVERS.
23.779	MOTION AND EFFECT OF COCKPIT CONTROLS	YES	SEE COMMENT CONCERNING SINGLE CONTROL LEVERS.
23.781	COCKPIT CONTROL KNOB SHAPE	YES	SEE COMMENT CONCERNING SINGLE CONTROL LEVERS.
23.783	DOORS.	YES	NONE
23.785	SEATS, BERTHS, LITTERS, SAFETY BELTS, AND SHOULDER HARNESSES	YES	NONE
23.787	BAGGAGE AND CARGO COMPARTMENTS	YES	NONE
23.791	PASSENGER INFORMATION SIGNS.	YES	NONE
23.803	EMERGENCY EVACUATION.	YES	NONE
23.805	FLIGHTCREW EMERGENCY EXITS.	YES	NONE
23.807	EMERGENCY EXITS.	YES	NONE
23.811	EMERGENCY EXIT MARKING.	YES	NONE
23.812	EMERGENCY LIGHTING.	YES	NONE
23.813	EMERGENCY EXIT ACCESS.	YES	NONE
23.815	WIDTH OF AISLE.	YES	NONE
23.831	VENTILATION.	YES	NONE
PRESSURIZATION			
23.841	PRESSURIZED CABINS.	YES	NONE
23.843	PRESSURIZATION TESTS.	YES	NONE

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SECTION	TITLE	APPLICABILITY	ANTICIPATED DIFFERENCES AND RATIONALE
FIRE PROTECTION			
23.851	FIRE EXTINGUISHERS.	YES	NONE
23.853	PASSENGER AND CREW COMPARTMENT INTERIORS	YES	NONE
23.855	CARGO AND BAGGAGE COMPARTMENT FIRE PROTECTION	YES	NONE
23.859	COMBUSTION HEATER FIRE PROTECTION	YES	NONE
23.863	FLAMMABLE FLUID FIRE PROTECTION	YES	NONE
23.865	FIRE PROTECTION OF FLIGHT CONTROLS, ENGINE MOUNTS, AND OTHER FLIGHT STRUCTURE	YES	NONE
ELECTRICAL BONDING AND LIGHTNING PROTECTION			
23.867	ELECTRICAL BONDING AND PROTECTION AGAINST LIGHTNING AND STATIC ELECTRICITY	YES	NONE
MISCELLANEOUS			
23.871	LEVELING MEANS.	YES	NONE
SUBPART E – POWERPLANT			
GENERAL			
23.901*	INSTALLATION.	YES	SEE COMMENT CONCERNING UNIQUE INSTALLATION CONCERNS: VIBRATION, ONE CYLINDER INOPERATIVE, CATASTROPHIC FAILURE. SPECIAL CONDITION(S) MAY APPLY – SEE PARAGRAPH TEXT.
23.903	ENGINES.	YES	SEE COMMENT CONCERNING UNIQUE INSTALLATION CONCERNS: STARTING AND STOPPING, RESTARTING ENVELOPE.
23.904	AUTOMATIC POWER RESERVE SYSTEM	YES	NONE
23.905	PROPELLERS.	YES	NONE
23.907*	PROPELLER VIBRATION.	YES	SEE COMMENT CONCERNING UNIQUE INSTALLATION CONCERNS: VIBRATION CHARACTERISTICS AND EFFECTS ON PROPELLERS. SPECIAL CONDITION(S) MAY APPLY – SEE PARAGRAPH TEXT.
23.909	TURBOCHARGER SYSTEMS.	YES	NONE
23.925	PROPELLER CLEARANCE.	YES	NONE
23.929	ENGINE INSTALLATION ICE PROTECTION	YES	NONE
23.933	REVERSING SYSTEMS.	YES	NONE
23.934	TURBOJET AND TURBOFAN ENGINE THRUST	YES	NONE
23.937	TURBOPROPELLER-DRAG LIMITING SYSTEMS.	YES	NONE
23.939	POWERPLANT OPERATING CHARACTERISTICS.	YES	NONE
23.943	NEGATIVE ACCELERATION.	YES	NONE

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SECTION	TITLE	APPLICABILITY	ANTICIPATED DIFFERENCES AND RATIONALE
FUEL SYSTEM			
23.951*	GENERAL.	YES	SEE COMMENT CONCERNING WATER ABSORBTION CHARACTERISTICS OF FUEL. NOTE: TURBINE ENGINE REQUIREMENTS ARE SOMETIMES MORE RELEVANT TO APPLY DUE TO THE NATURE OF THE ADE FUEL. SPECIAL CONDITION(S) MAY APPLY – SEE PARAGRAPH TEXT.
23.953	FUEL SYSTEM INDEPENDENCE.	YES	NONE
23.954	FUEL SYSTEM LIGHTNING PROTECTION	YES	NONE
23.955*	FUEL FLOW.	YES	SEE COMMENT CONCERNING FUEL TEMPERATURE AND FUEL PUMP REQUIREMENTS. NOTE: TURBINE ENGINE REQUIREMENTS ARE SOMETIMES MORE RELEVANT TO APPLY DUE TO THE NATURE OF THE ADE FUEL. SPECIAL CONDITION(S) MAY APPLY – SEE PARAGRAPH TEXT.
23.957	FLOW BETWEEN INTERCONNECTED TANKS	YES	NONE
23.959	UNUSABLE FUEL SUPPLY.	YES	NONE
23.961	FUEL SYSTEM HOT WEATHER OPERATION	YES	SEE COMMENT CONCERNING FUEL TEMPERATURE.
23.963	FUEL TANKS: GENERAL.	YES	NONE
23.965	FUEL TANK TESTS.	YES	NONE
23.967	FUEL TANK INSTALLATION.	YES	NONE
23.969	FUEL TANK EXPANSION SPACE	YES	NONE
23.971	FUEL TANK SUMP.	YES	SEE COMMENT FUEL SUMP.
23.973*	FUEL TANK FILLER CONNECTION	YES	SEE COMMENT CONCERNING FUEL FILLER AND ALSO PLACARD AS CALLED OUT IN 23.1557. NOTE: TURBINE ENGINE REQUIREMENTS ARE SOMETIMES MORE RELEVANT TO APPLY DUE TO THE NATURE OF THE ADE FUEL. SPECIAL CONDITION(S) MAY APPLY – SEE PARAGRAPH TEXT.
23.975	FUEL TANK VENTS AND CARBURETOR VAPOR VENTS	YES	NONE
23.977*	FUEL TANK OUTLET.	YES	SEE COMMENT CONCERNING FUEL FILTRATION AND POSSIBILITY OF INJECTION BLOCKAGE. NOTE: TURBINE ENGINE REQUIREMENTS ARE SOMETIMES MORE RELEVANT TO APPLY DUE TO THE NATURE OF THE ADE FUEL. SPECIAL CONDITION(S) MAY APPLY – SEE PARAGRAPH TEXT.
23.979	PRESSURE FUELING SYSTEMS.	YES	NONE
FUEL SYSTEM COMPONENTS			
23.991	FUEL PUMPS.	YES	SEE COMMENT CONCERNING FUEL DELIVERY. NOTE: TURBINE ENGINE REQUIREMENTS ARE SOMETIMES MORE RELEVANT TO APPLY DUE TO THE NATURE OF THE ADE OPERATION.
23.993	FUEL SYSTEM LINES AND FITTINGS	YES	NONE
23.994	FUEL SYSTEM COMPONENTS.	YES	NONE
23.995	FUEL VALVES AND CONTROLS	YES	NONE
23.997	FUEL STRAINER OR FILTER	YES	SEE COMMENT CONCERNING FUEL FILTRATION AND POSSIBILITY OF INJECTION BLOCKAGE. NOTE: TURBINE ENGINE REQUIREMENTS ARE SOMETIMES MORE RELEVANT TO APPLY DUE TO THE NATURE OF THE ADE FUEL.
23.999	FUEL SYSTEM DRAINS.	YES	NONE
23.1001	FUEL JETTISONING SYSTEM.	YES	NONE

PART 21 AND 23 – AIRWORTHINESS STANDARDS: NORMAL, UTILITY, ACROBATIC, AND COMMUTER CATEGORY AIRPLANES: AFFECTED REGULATIONS			
SECTION	TITLE	APPLICABILITY	ANTICIPATED DIFFERENCES AND RATIONALE
OIL SYSTEM			
23.1011	GENERAL.	YES	NONE
23.1013	OIL TANKS.	YES	NONE
23.1015	OIL TANK TESTS.	YES	NONE
23.1017	OIL LINES AND FITTINGS	YES	NONE
23.1019	OIL STRAINER OR FILTER	YES	NONE
23.1021	OIL SYSTEM DRAINS.	YES	NONE
23.1023	OIL RADIATORS.	YES	NONE
23.1027	PROPELLER FEATHERING SYSTEM.	YES	NONE
COOLING			
23.1041	GENERAL.	YES	NONE
23.1043	COOLING TESTS.	YES	NONE
23.1045	COOLING TEST PROCEDURES FOR TURBINE ENGINE POWERED AIRPLANES	YES	NONE
23.1047	COOLING TEST PROCEDURES FOR RECIPROCATING ENGINE POWERED AIRPLANES	YES	NONE
LIQUID COOLING			
23.1061	INSTALLATION.	YES	NONE
23.1063	COOLANT TANK TESTS.	YES	NONE
INDUCTION SYSTEM			
23.1091	AIR INDUCTION SYSTEM.	YES	NONE
23.1093	INDUCTION SYSTEM ICING PROTECTION	YES	NONE
23.1095	CARBURETOR DEICING FLUID FLOW RATE	YES	NONE
23.1097	CARBURETOR DEICING FLUID SYSTEM CAPACITY	YES	NONE
23.1099	CARBURETOR DEICING FLUID SYSTEM DETAIL DESIGN	YES	NONE
23.1101	INDUCTION AIR PREHEATER DESIGN	YES	NONE
23.1103	INDUCTION SYSTEM DUCTS.	YES	NONE
23.1105	INDUCTION SYSTEM SCREENS.	YES	NONE
23.1107	INDUCTION SYSTEM FILTERS.	YES	NONE
23.1109	TURBOCHARGER BLEED AIR SYSTEM	YES	NONE
23.1111	TURBINE ENGINE BLEED AIR SYSTEM	YES	NONE
EXHAUST SYSTEM			
23.1121	GENERAL.	YES	NONE
23.1123	EXHAUST SYSTEM.	YES	NONE
23.1125	EXHAUST HEAT EXCHANGERS.	YES	NONE
POWERPLANT CONTROLS AND ACCESSORIES			
23.1141	POWERPLANT CONTROLS: GENERAL.	YES	NONE
23.1142	AUXILIARY POWER UNIT CONTROLS	YES	NONE
23.1143	ENGINE CONTROLS.	YES	NONE

PART 21 AND 23 – AIRWORTHINESS STANDARDS: NORMAL, UTILITY, ACROBATIC, AND COMMUTER CATEGORY AIRPLANES: AFFECTED REGULATIONS			
SECTION	TITLE	APPLICABILITY	ANTICIPATED DIFFERENCES AND RATIONALE
23.1145*	IGNITION SWITCHES.	YES	SEE COMMENT CONCERNING USAGE OF 'IGNITION SWITCH' AS A MEANS OF ENGINE SHUTDOWN; IT IS REALIZED THAT 'IGNITION SWITCH' IS A MISNOMER WHEN CONCERNED WITH ADE. SPECIAL CONDITION(S) MAY APPLY – SEE PARAGRAPH TEXT.
23.1147	MIXTURE CONTROLS.	YES	NONE
23.1149	PROPELLER SPEED AND PITCH CONTROLS	YES	NONE
23.1153	PROPELLER FEATHERING CONTROLS.	YES	NONE
23.1155	TURBINE ENGINE REVERSE THRUST AND PROPELLER PITCH SETTINGS BELOW THE FLIGHT REGIME	YES	NONE
23.1157	CARBURETOR AIR TEMPERATURE CONTROLS	YES	NONE
23.1163	POWERPLANT ACCESSORIES.	YES	NONE
23.1165*	ENGINE IGNITION SYSTEMS.	YES	SEE COMMENT CONCERNING FADEC USAGE. SPECIAL CONDITION(S) MAY APPLY – SEE PARAGRAPH TEXT.
POWERPLANT FIRE PROTECTION			
23.1181	DESIGNATED FIRE ZONES; REGIONS INCLUDED	YES	NONE
23.1182	NACELLE AREAS BEHIND FIREWALLS	YES	NONE
23.1183	LINES, FITTINGS, AND COMPONENTS	YES	NONE
23.1189	SHUTOFF MEANS.	YES	NONE
23.1191	FIREWALLS.	YES	NONE
23.1192	ENGINE ACCESSORY COMPARTMENT DIAPHRAGM	YES	NONE
23.1193	COWLING AND NACELLE.	YES	NONE
23.1195	FIRE EXTINGUISHING SYSTEMS MATERIALS.	YES	NONE
23.1197	FIRE EXTINGUISHING AGENTS.	YES	NONE
23.1199	EXTINGUISHING AGENT CONTAINERS.	YES	NONE
23.1201	FIRE EXTINGUISHING SYSTEMS	YES	NONE
23.1203	FIRE DETECTOR SYSTEM.	YES	NONE
SUBPART F -- EQUIPMENT			
GENERAL			
23.1301	FUNCTION AND INSTALLATION.	YES	NONE
23.1303	FLIGHT AND NAVIGATION INSTRUMENTS	YES	NONE
23.1305*	POWERPLANT INSTRUMENTS.	YES	SEE COMMENT CONCERNING UNIQUE INSTRUMENTATION REQUIRED FOR ADE OPERATION. SPECIAL CONDITION(S) MAY APPLY – SEE PARAGRAPH TEXT.
23.1307	MISCELLANEOUS EQUIPMENT.	YES	NONE
23.1309	EQUIPMENT, SYSTEMS, AND INSTALLATIONS.	YES	NONE
INSTRUMENTS: INSTALLATION			
23.1311	ELECTRONIC DISPLAY INSTRUMENT SYSTEMS	YES	NONE
23.1321	ARRANGEMENT AND VISIBILITY.	YES	NONE

PART 21 AND 23 – AIRWORTHINESS STANDARDS: NORMAL, UTILITY, ACROBATIC, AND COMMUTER CATEGORY AIRPLANES: AFFECTED REGULATIONS			
SECTION	TITLE	APPLICABILITY	ANTICIPATED DIFFERENCES AND RATIONALE
23.1322	WARNING, CAUTION, AND ADVISORY LIGHTS	YES	NONE
23.1323	AIRSPEED INDICATING SYSTEM.	YES	NONE
23.1325	STATIC PRESSURE SYSTEM.	YES	NONE
23.1326	PITOT HEAT INDICATION SYSTEMS	YES	NONE
23.1327	MAGNETIC DIRECTION INDICATOR.	YES	NONE
23.1329	AUTOMATIC PILOT SYSTEM.	YES	NONE
23.1331	INSTRUMENTS USING A POWER SOURCE	YES	NONE
23.1335	FLIGHT DIRECTOR SYSTEMS.	YES	NONE
23.1337	POWERPLANT INSTRUMENTS INSTALLATION.	YES	NONE
ELECTRICAL SYSTEMS AND EQUIPMENT			
23.1351	GENERAL.	YES	NONE
23.1353	STORAGE BATTERY DESIGN AND INSTALLATION	YES	NONE
23.1357	CIRCUIT PROTECTIVE DEVICES.	YES	NONE
23.1359	ELECTRICAL SYSTEM FIRE PROTECTION	YES	NONE
23.1361	MASTER SWITCH ARRANGEMENT.	YES	NONE
23.1365	ELECTRIC CABLES AND EQUIPMENT	YES	NONE
23.1367	SWITCHES.	YES	NONE
LIGHTS			
23.1381	INSTRUMENT LIGHTS.	YES	NONE
23.1383	TAXI AND LANDING LIGHTS	YES	NONE
23.1385	POSITION LIGHT SYSTEM INSTALLATION	YES	NONE
23.1387	POSITION LIGHT SYSTEM DIHEDRAL ANGLES	YES	NONE
23.1389	POSITION LIGHT DISTRIBUTION AND INTENSITIES	YES	NONE
23.1391	MINIMUM INTENSITIES IN THE HORIZONTAL PLANE OF POSITION LIGHTS	YES	NONE
23.1393	MINIMUM INTENSITIES IN ANY VERTICAL PLANE OF POSITION LIGHTS	YES	NONE
23.1395	MAXIMUM INTENSITIES IN OVERLAPPING BEAMS OF POSITION LIGHTS	YES	NONE
23.1397	COLOR SPECIFICATIONS.	YES	NONE
23.1399	RIDING LIGHT.	YES	NONE
23.1401	ANTICOLLISION LIGHT SYSTEM.	YES	NONE
SAFETY EQUIPMENT			
23.1411	GENERAL.	YES	NONE
23.1415	DITCHING EQUIPMENT.	YES	NONE
23.1416	PNEUMATIC DE-ICER BOOT SYSTEM	YES	NONE
23.1419	ICE PROTECTION.	YES	NONE
MISCELLANEOUS EQUIPMENT			
23.1431	ELECTRONIC EQUIPMENT.	YES	NONE
23.1435	HYDRAULIC SYSTEMS.	YES	NONE
23.1437	ACCESSORIES FOR MULTI-ENGINE AIRPLANES	YES	NONE

PART 21 AND 23 – AIRWORTHINESS STANDARDS: NORMAL, UTILITY, ACROBATIC, AND COMMUTER CATEGORY AIRPLANES: AFFECTED REGULATIONS			
SECTION	TITLE	APPLICABILITY	ANTICIPATED DIFFERENCES AND RATIONALE
23.1438	PRESSURIZATION AND PNEUMATIC SYSTEMS	YES	NONE
23.1441	OXYGEN EQUIPMENT AND SUPPLY	YES	NONE
23.1443	MINIMUM MASS FLOW OF SUPPLEMENTAL OXYGEN	YES	NONE
23.1445	OXYGEN DISTRIBUTION SYSTEM.	YES	NONE
23.1447	EQUIPMENT STANDARDS FOR OXYGEN DISPENSING UNITS	YES	NONE
23.1449	MEANS FOR DETERMINING USE OF OXYGEN	YES	NONE
23.1450	CHEMICAL OXYGEN GENERATORS.	YES	NONE
23.1451	FIRE PROTECTION FOR OXYGEN EQUIPMENT	YES	NONE
23.1453	PROTECTION OF OXYGEN EQUIPMENT FROM RUPTURE	YES	NONE
23.1457	COCKPIT VOICE RECORDERS.	YES	NONE
23.1459	FLIGHT RECORDERS.	YES	NONE
23.1461	EQUIPMENT CONTAINING HIGH ENERGY ROTORS	YES	NONE
SUBPART G – OPERATING LIMITATIONS AND INFORMATION			
23.1501	GENERAL.	YES	NONE
23.1505	AIRSPEED LIMITATIONS.	YES	NONE
23.1507	OPERATING MANEUVERING SPEED.	YES	NONE
23.1511	FLAP EXTENDED SPEED.	YES	NONE
23.1513	MINIMUM CONTROL SPEED.	YES	NONE
23.1519	WEIGHT AND CENTER OF GRAVITY	YES	NONE
23.1521*	POWERPLANT LIMITATIONS.	YES	SEE COMMENT CONCERNING UNIQUE OPERATIONAL REQUIREMENTS FOR ADE. SPECIAL CONDITION(S) MAY APPLY – SEE PARAGRAPH TEXT.
23.1522	AUXILIARY POWER UNIT LIMITATIONS	YES	NONE
23.1523	MINIMUM FLIGHT CREW.	YES	NONE
23.1524	MAXIMUM PASSENGER SEATING CONFIGURATION	YES	NONE
23.1525	KINDS OF OPERATION.	YES	NONE
23.1527	MAXIMUM OPERATING ALTITUDE.	YES	NONE
23.1529	INSTRUCTIONS FOR CONTINUED AIRWORTHINESS	YES	NONE
MARKINGS AND PLACARDS			
23.1541	GENERAL.	YES	NONE
23.1543	INSTRUMENT MARKINGS: GENERAL.	YES	NONE
23.1545	AIRSPEED INDICATOR.	YES	NONE
23.1547	MAGNETIC DIRECTION INDICATOR.	YES	NONE
23.1549	POWERPLANT AND AUXILIARY POWER UNIT INSTRUMENTS	YES	NONE
23.1551	OIL QUANTITY INDICATOR.	YES	NONE
23.1553	FUEL QUANTITY INDICATOR.	YES	NONE
23.1555	CONTROL MARKINGS.	YES	NONE
23.1557*	MISCELLANEOUS MARKINGS AND PLACARDS	YES	SEE COMMENT CONCERNING FUEL PLACARD FOR ADE. SPECIAL CONDITION(S) MAY APPLY – SEE PARAGRAPH TEXT.
23.1559	OPERATING LIMITATIONS PLACARD.	YES	NONE
23.1561	SAFETY EQUIPMENT.	YES	NONE
23.1563	AIRSPEED PLACARDS.	YES	NONE

PART 21 AND 23 – AIRWORTHINESS STANDARDS: NORMAL, UTILITY, ACROBATIC, AND COMMUTER CATEGORY AIRPLANES: AFFECTED REGULATIONS			
SECTION	TITLE	APPLICABILITY	ANTICIPATED DIFFERENCES AND RATIONALE
23.1567	FLIGHT MANEUVER PLACARD.	YES	NONE
AIRPLANE FLIGHT MANUAL AND APPROVED MANUAL MATERIAL			
23.1581	GENERAL.	YES	NONE
23.1583	OPERATING LIMITATIONS.	YES	SEE COMMENT CONCERNING UNIQUE OPERATIONAL REQUIREMENTS FOR ADE.
23.1585	OPERATING PROCEDURES.	YES	SEE COMMENT CONCERNING UNIQUE OPERATIONAL REQUIREMENTS FOR ADE.
23.1587	PERFORMANCE INFORMATION.	YES	NONE
23.1589	LOADING INFORMATION.	YES	NONE

II. Section Discussions

Part 21

Primary Category

An aircraft diesel engine design cannot be approved as part of an airframe TC under a primary category approval. The intent of primary category is a simple aircraft, and the aircraft diesel engine does not have any service history to warrant approval in the primary category without prior engine certification. It would be allowable, per part 33, to put a certified diesel engine in a primary category airplane. This position may change once the service history of the aircraft diesel engine is established.

Airships

The technical concerns mentioned in this policy should also be considered with respect to airship projects.

Legacy Aircraft Diesel Engines

There are three certificated diesel airplane engines from the 1930's and 1940's that the FAA is aware of:

Packard DR-980	ATC 43	1930
Guiberson A-980	ATC 79	
Guiberson A-1020	TC 220	

(ATC -- Approved Type Certificate, TC -- Type Certificate).

The Packard went into limited trial service, and there is no knowledge if either of the Guiberson engines went into aircraft service. In the unlikely event that one of these engines is proposed for installation, existing changed product policy should be applied, depending on the vintage of the airframe to be used. The reliability of the Packard is considered substandard to conventional reciprocating engines of the same period, and if any of the Packard engines is to be installed in an airplane for other than experimental purposes, this must be considered. It is extremely unlikely that any of the remaining Guiberson engines could be brought into suitable condition for installation in an aircraft, but similar considerations would apply.

Some of the original known airplane Packard diesel engine installation combinations include the following (some of these may not have been approved for standard operations): Army (Consolidated) primary trainer, Bellanca "six place," Bellanca Special, Buhl Air Sedan, Ford Tri-Motor, Ryan "four place," Stewart Twin, Stinson Detroiter, Stinson Junior, Towle Amphibian, Verville Air Coach, and Waco Straight Wing.

§ 21.19 -- Changes Requiring a New Type Certificate

You may install a certificated aircraft diesel engine into a certificated airplane using either the STC or ATC process. You may not install a certificated diesel engine into a certificated airplane through a field approval. The design requirements appropriate to the aircraft diesel engine and its systems along with historical precedents justify this rationale.

§ 21.21(b)(2) Issue of Type Certificate; Normal, Utility, Acrobatic, Commuter, and Transport Category Aircraft; Manned Free Balloons; Special Classes of Aircraft; Aircraft Engines; Propellers (Special Condition -- Engine Vibration)

§ 21.21(b) states:

The applicant submits the type design, test reports, and computations necessary to show that the product to be certificated meets the applicable airworthiness, aircraft noise, fuel venting, and exhaust emission requirements of the Federal Aviation Regulations and any special conditions prescribed by the Administrator, and the Administrator finds—

§ 21.21(b)(2) states:

For an aircraft, that no feature or characteristic makes it unsafe for the category in which certification is requested.

Given the lack of field service history on aircraft diesel engines, the following special conditions will most likely be required for diesel engine installations:

(1) No unsafe condition will exist in case of an inoperable cylinder until the engine can be shut down and the resistance of the propeller, engine mount, and airframe structure to shaking moment/vibration damage is investigated. It must be shown that the shaking and vibration damage from the engine (caused by an inoperative cylinder) will not cause a catastrophic airframe failure and no unsafe condition will exist.

(2) The propeller utilized on the engine must be certificated to survive such an event without catastrophic failure. The concern is a catastrophic failure of the propeller in case of an inoperable cylinder.

Part 23

Subpart B – Flight

General Comment: As with all air breathing engines, a diesel engine will lose performance at lower intake air densities. The rate of change will be different for a diesel than either a conventional reciprocating engine (including turbocharged

or supercharged) or a turbine engine. The airplane performance effects need to be understood and documented in the airplane flight manual. Airplane engine conversions should be evaluated thoroughly because a diesel engine's standard day rating may not be directly comparable to a conventional reciprocating engine. In addition, the power-off glide characteristics with an aircraft diesel engine may be substantially different due to the effect of a wind milling or stopped propeller.

§ 23.251 -- Vibration and Buffeting

As part of the basic compliance efforts for aircraft diesel-powered engine airplanes, the effects of vibration levels higher than those typical for conventional reciprocating engine powered airplanes must be considered. The concern is for engine excitation of the airframe within the certification flight envelope, especially at the limits of the flight envelope.

Subpart C -- Structure

§ 23.361 paragraphs (b)(1) and (c)(3) -- Engine Torque

The sudden stoppage criterion used for turbine engines is considered appropriate for aircraft diesel engines. The sudden stoppage criterion is considered appropriate due to the much greater cylinder pressures and the potentially more severe failure mode of an aircraft diesel engine. This may be applicable via a special condition. The applicant can develop, in lieu of this, data that would show that an ELOS would be demonstrated with similar installations.

The factor of four, for aircraft diesel engines with four cylinders or more, will be used to multiply the aircraft diesel engine's mean torque to calculate the limit torque; this is due to the higher expected load levels in the diesel engines. In the case of an aircraft diesel engine with less than four cylinders, the FAA will consider this on a case-by-case basis. This may be applicable via a special condition. The applicant can develop, in lieu of this, data that would show that an ELOS would be demonstrated with similar installations.

§ 23.572 -- Metallic Wing, Empennage, and Associated Structure

As part of the basic compliance efforts for aircraft diesel engine powered airplanes, the effects of vibration levels higher than those typical for conventional reciprocating engine powered airplanes must be considered. There are no additional tests other than the basic compliance requirements. The vibration surveys would be conducted at various points throughout the flight envelope and the data would be analyzed against the structure fatigue characteristics. The concern is for any adverse effects on fatigue characteristics of the airframe.

The added weight due to the increased density of diesel fuel compared to AvGas will need to be evaluated when an aircraft diesel engine is being installed via STC into an already certificated aircraft. AC 23-7 provides the appropriate guidance.

§ 23.573 -- Damage Tolerance and Fatigue Evaluation Structure

As part of the basic compliance efforts for aircraft diesel engine powered airplanes, the effects of vibration levels higher than those typical for conventional reciprocating engine powered airplanes must be considered. Our concern is for any adverse effects on fatigue characteristics of the airframe.

§ 23.574 – Metallic Damage Tolerance and Fatigue Evaluation Structure of Commuter Category Airplanes

As part of the basic compliance efforts for aircraft diesel engine powered airplanes, the effects of vibration levels higher than those typical for conventional reciprocating engine powered airplanes must be considered. Our concern is for any adverse effects on fatigue characteristics of the airframe.

Subpart D -- Design and Construction

§ 23.613 -- Material Strength Properties and Design Values

As part of the basic compliance efforts for aircraft diesel engine-powered airplanes, the effects of vibration levels higher than those typical for conventional reciprocating engine powered airplanes must be considered. Our concern is any adverse effects on fatigue characteristics of the airframe.

§ 23.627 -- Fatigue Strength

As part of the basic compliance efforts for an aircraft diesel engine airplane, the effects of higher vibration levels that might be higher than those typical for conventional reciprocating engine powered airplanes must be considered. Our concern is for any adverse effects on fatigue characteristics of the airframe.

§ 23.629, paragraphs (e)(1) and (2) -- Flutter

The vibration levels of the aircraft diesel engine will most likely require the application of the turbopropeller requirements by a special condition. Considerations for vibration levels, including those with an inoperative cylinder, will need to be evaluated. Our concern is for engine excitation of the airframe within the certification flight envelope.

When installing an aircraft diesel engine in an airplane, the applicant will show by test or analysis, or by a combination of methods, that, in the event of an inoperative cylinder, the airframe can withstand the shaking or vibratory forces

imposed by the engine. Diesel engines of conventional design typically have extremely high levels of vibration in the case of an inoperative cylinder. The engine manufacturer should provide data to the airframe installer/modifier so that either of those appropriate design considerations or operating procedures, or both, can be developed to prevent airframe damage.

Under § 21.21(b)(2), the following requirement appears: No feature or characteristic makes the aircraft unsafe for the category in which certification is requested. This is of particular concern during an airplane engine conversion as the original design data is often not available and the engine/propeller is apt to be heavier as well as being subjected to higher vibratory loads. As described earlier in this policy statement, there is a potential special condition applied to § 21.21(b)(2) concerning the one cylinder inoperative scenario and its potential to be an unsafe condition.

§ 23.629(i) -- Flutter

Considerations for vibration levels, including those with an inoperative cylinder, will need to be evaluated. Our concern is for engine excitation of the airframe within the certification flight envelope.

Care must be taken for older aircraft, which will be changed and which have been certificated against a lower level of airworthiness requirements. Principal ground vibration tests will most likely be necessary to show compliance with § 23.629 in terms of symmetric/asymmetric coupling between engine mass and empennage, especially elevator and horizontal stabilizer structure.

§ 23.777(d) -- Cockpit Controls

If a single power lever/single power control is used, the applicant will need to request an ELOS per AC 23-17A guidance.

§ 23.779(b) -- Motion and Effect of Cockpit Controls

If a single power lever/single power control is used, the applicant will need to request an ELOS per AC 23-17A guidance.

§ 23.781 -- Cockpit Control Knob Shape

If a single power lever/single power control is used, the applicant will need to request an ELOS per AC 23-17A guidance.

Subpart E -- Powerplant

§ 23.901 -- Installation

Based on limited historical precedent, but also on the fact that much higher cylinder pressures exist in diesel engines, the possibility that engine failures may lead to liberation of high energy engine fragments must be evaluated. The applicant will submit a safety analysis that addresses the engine construction and possible failure modes.

The engine manufacturer should perform the safety analysis and supply the safety analysis as part of the engine design data. If the safety analysis indicates that there may be an engine failure mode that will liberate engine parts, then the design features of the airplane must be configured to minimize the hazard to crew, controls, and passengers. If the engine has failure modes that will liberate parts, then consequences of the failure must be analyzed and minimized; i.e., the probability of the failure will be 100 percent. Mitigation of the failure hazard must include reasonable design features to achieve minimization and not merely be an analysis of the final design. This requirement may be applied with a special condition.

§ 23.901(d)(1) -- Installation

The vibration levels of the aircraft diesel engine, if greater than those for conventional reciprocating engines, may require the application of this turbine engine requirement by a special condition. Considerations for vibration levels, including those with an inoperative cylinder, will need to be evaluated.

When installing an aircraft diesel engine in an airplane, the applicant will show by test or analysis, or by a combination of methods, that in the event of an inoperative cylinder the engine and airframe can withstand the shaking or vibratory forces imposed by the engine. Diesel engines of conventional design typically have extremely high levels of vibration in the case of an inoperative cylinder. The engine manufacturer should provide data to the airframe installer/modifier so that either of those appropriate design considerations or operating procedures, or both, can be developed to prevent airframe damage.

Under § 21.21(b)(2), the following requirement appears: No feature or characteristic makes the aircraft unsafe for the category in which certification is requested. This is of particular concern during an airplane engine conversion as the original design data is often not available and the engine/propeller is apt to be heavier as well as being subjected to higher vibratory loads. As described earlier in this policy statement, there is a potential special condition applied to § 21.21(b)(2) concerning the one cylinder inoperative scenario and its potential to be an unsafe condition.

There is no existing requirement for conventional reciprocating engines to ensure that the installed engine does not exceed the engine's vibratory limit under all operating conditions. This requirement is in § 23.901(d)(1) and is applicable to turbine engines only. A special condition may be needed to impose this requirement on any airplanes that use an aircraft diesel engine.

§ 23.903(f) -- Engines

Diesel engine starting systems may utilize unconventional starting technology. Due to high compression levels of the diesel engine (or possibly environmental conditions), air starters or other systems may be used that may be expended or that have recharge times. Also, high-pressure fuel systems are more susceptible to air lock conditions during altitude restart situations. Limitations may have to be added that address these design features. This would be considered a basic compliance issue.

§ 23.907 -- Propeller Vibration

The power cycle of the diesel engine is fundamentally different from a conventional reciprocating engine and may impose unacceptable loads, vibration levels, and vibration modes on propellers that have previously been approved and considered acceptable for gasoline or turbine engine installations. Propeller vibration requirements must be substantiated by testing, as conventional propellers might not be robust enough to use on a diesel engine.

Aircraft diesel engine crankshafts typically have high first order torsionals, the propeller is likely to be quite rugged and possibly contain new and unusual design characteristics. For the initial installations, the listing of propeller combinations approved vibration wise in a propeller TCDS, Note 9, would not be considered to be a showing of compliance to § 23.907. The applicant must perform a vibration test and analysis to determine engine/propeller/airframe compatibility prior to the approval of the (certificated) engine and propeller installation in a certificated airplane.

§ 23.907(a)	Fixed pitch wooden propellers may not be excluded from the requirement. The requirement may be applied via special condition.
§ 23.907(a)(1)	Required.
§ 23.907(a)(2)	Not acceptable for diesel engine installations at this time.
§ 23.907(a)(3)	Service history may not be acceptable for new technology.
§ 23.907(b)	Fixed pitch wooden propellers will not be excluded. The requirement will be applied via special condition.

§ 23.951(c) -- Fuel System -- General

The airplane will comply with the requirements of part 23, § 23.951(c), as kerosene-based fuels absorb greater amounts of water than gasoline fuels and have a much greater potential for fuel system icing.

Some turbine engine powered airplanes have complied with this requirement by mandating the utilization of fuel anti-icing additives. Mandating the use of anti-icing additives would be an acceptable method to show compliance; however, the use of these additives is generally being curtailed in some countries for environmental reasons. A special condition will likely be required to impose the requirements of § 23.951(c) on any airplanes that use an aircraft diesel engine and operate on kerosene-based fuels.

§ 23.955(a) -- Fuel Flow -- General

See the discussion concerning fuel temperature under § 23.961, § 23.1521(e) and fuel temperature limitations.

§ 23.955, paragraphs (c) and (f) -- Fuel Flow -- Pump Systems

The minimum flow requirements of § 23.955(c) apply to pump systems for conventional reciprocating engines. The requirement was developed to prevent detonation by ensuring that a rich mixture could always be attained. The turbine engine requirements of § 23.955(f) are more suitable to an aircraft diesel engine because a diesel engine, which already operates lean of stoichiometric, does not have the same need to ensure a rich operating condition to prevent engine damage. The certificated engine will address the issue of "detonation margin" and, if required, the 100 percent requirement of § 23.955(f) will be adjusted accordingly. The requirement will be applied by a special condition if applicable to the installation.

§ 23.961 -- Fuel System Hot Weather Operation

The engine fuel injection system will most likely provide a high volume of return fuel. This may lead to an excessive temperature rise of the fuel. The acceptable fuel temperature limitation required by shall not be exceeded. A test has to be performed to determine the fuel temperature under the worst condition. The hot fuel test has to be performed under these conditions.

§ 23.971(c) -- Fuel Tank Sump

The purpose of the sediment bowl of the configuration specified in § 23.971(c) is to remove any water that separates from the gasoline. Water is more soluble in kerosene fuels than in gasoline and a fuel sediment bowl may not be necessary

based upon the experience of turbine powered airplanes. This section might be deemed "not applicable" for an aircraft diesel engine.

§ 23.973(f) -- Fuel Tank Filler Connection

The fuel filler nozzle for turbine engine fuel (Jet-A) is larger than the corresponding fuel filler nozzle for conventional reciprocating engine fuel (100LL). In order to minimize the potential for mis-fueling, the airplane should comply with the requirements of § 23.973(f) in lieu of § 23.973(e). Also, see the § 23.1557 discussion in this policy statement. The requirement may be applied by a special condition.

§ 23.977(a)(2) -- Fuel Tank Outlet

The strainer size must be appropriate for the aircraft diesel engine fuel requirements, especially considering eliminating the possibility of injector and pump contamination. The airplane should comply with the requirements of § 23.977(a)(2) in lieu of § 23.977(a)(1). The requirement may be applied by a special condition.

§ 23.991 -- Fuel Pumps,
§ 23.993 -- Fuel System Lines and Fittings,
§ 23.994 -- Fuel System Components,
§ 23.995 -- Fuel Valves and Controls,
§ 23.997 -- Fuel Strainer or Filter

Fuel system components designed for small airplanes may be optimized or designed for low-pressure gasoline systems. Components that will be exposed to the effects of high-pressure pumps will need to be designed to account for the effects of high pressure and fatigue, perhaps similar to requirements for hydraulic systems. Turbine fuels may have additives added after they are refined that modify fuel properties associated with airplane icing, biological contamination, static buildup, flow improvement, weathering, and temperature stability. Frequently, it cannot be determined if these additives are in the fuel that is delivered to the airplane.

Over-wing fueling systems at airports may not have the same source as pressure fueling systems for large transport airplanes and may contain different additives. Determine whether the aircraft fuel system components are compatible with the fuel and with any potential additive that could be introduced into the fuel.

The military are utilizing some additives to increase the thermal stability of jet fuels that are not commercially utilized. The potential effects of these additives on the systems of small airplanes will need to be examined if there is any possibility of the airplane being operated on military fuels. In addition to material

properties, the effects on fuel gauging systems, and the effects on filtering systems/media will need to be specifically evaluated.

Kerosene fuels can potentially produce an explosive or flammable mixture in the fuel tanks at normal operating temperatures while gasoline mixtures in the fuel tanks are typically beyond the rich limit. Fuel tank ignition sources need to be eliminated over the total life cycle of the airplane, and extreme care should be used when converting the fuel system of an airplane from gasoline to kerosene-based fuels. Grounding of all metal components within the fuel tank is perhaps more important with diesel powered engines (relative to gasoline) to ensure common potential (and, therefore, no arcing) between the metal components and the inrushing fuel, which is something to consider in STC re-engine projects. Also, re-evaluation of fuel quantity indicating systems for compatibility, ignition source, and marking requirements should be considered.

In some ground-based diesel engine designs, fuel line pressures have been known to exceed 3,000 psi, which is significantly higher than conventional turbine engine fuel systems. Extra attention should be given to fuel system components and the instructions for continued airworthiness for the system and its components. Basic compliance addressing the specific design challenges of the aircraft diesel engine systems will be adequate.

§ 23.1145 -- Ignition Switches

This requirement will have to be modified to incorporate an appropriate means of stopping the engine. In place of the basic requirement, there must be a means to stop the engine; this may mean shutting off the engine control (FADEC, or similar) or appropriate components. Depending on specific system details, a special condition, exemption or ELOS for § 23.1145 could be utilized.

As the diesel engine is a compression ignition engine, the ignition source is the heat created by compressing the air-fuel mixture in the cylinder. Section 23.1145(a) would not be applicable. Part of the intent of § 23.1145(b) is to have a method available to the crew to quickly stop an engine(s). As a diesel engine does not have an ignition system, an alternate means of rapidly stopping an engine(s) would need to be provided and addressed via a special condition, exemption or ELOS.

§ 23.1165 – Engine Ignition Systems (Permanent electrical power)

Modern diesel engines will most likely be equipped with EEC or FADEC. These systems need permanent electrical power. Battery ignition systems are addressed in § 23.1165. The need for permanent electrical power is identical to the EEC/FADEC Electrical Power requirement. The EEC/FADEC system will have the same critical function as the battery ignition system identified in § 23.1165. This requirement will need to be addressed via a special condition or ELOS.

Since the electronic engine control without mechanical backup requires permanent electric power, the criticality of the power supply system may be higher than on a conventional magneto ignition system. The § 23.1309 assessment (FHA and FMEA) has to address this failure mode. If the electric power after loss of generator is limited to a specific time (e.g., if supplied by battery), this remaining time should be demonstrated and the information should be in the POH. The time required in § 23.1353(h) may not establish the same level of safety as a conventional magneto ignition system. In any case, the pilot should be informed that the engine will stop if the electric power is lost (POH).

§ 23.1203(a)(1)(ii) -- Fire Detector System

If the aircraft diesel engine is installed on a multi-engine airplane and the engine utilizes turbochargers, this section will apply. Basic compliance is adequate.

Subpart F -- Equipment

§ 23.1305 -- Powerplant Instruments

The installation of an aircraft diesel engine will be in accordance with the engine's installation manual and operated within the requirements of its TC. The instrumentation requirements in § 23.1305 were written for conventional reciprocating engines and turbine engines. The requirement did not envision the use of aircraft diesel engines. In addition, instrumentation may be determined necessary for a particular installation that is not specified in the current requirements or the engine's installation manual. Should the aircraft diesel engine limiting parameters be different than those specified in § 23.1521, special conditions will most likely be developed to require those parameters to be used as limitations (see § 23.1521). The limiting parameters will be displayed in the instrument panel as required by § 23.1305. Also, see § 23.1521 for fuel temperature limitations.

Special conditions will most likely be developed if any additional items to those specified in § 23.1305(b), or items described under § 23.1305, paragraphs (c), (d), or (e), are required.

Any deletions from the parameters required by § 23.1305(b) could be administered via an exemption through the development of an equivalent level of safety or in combination with any special conditions requiring additional parameters.

Subpart G -- Operating Limitations and Information

§ 23.1521 -- Powerplant Limitations

General Comment: An aircraft diesel engine may have different critical parameters than conventional reciprocating engines. Should the aircraft diesel engine limiting parameters be different than those specified in § 23.1521, special conditions will most likely be developed to require those parameters to be used as limitations. Also see the discussion for § 23.1305.

Section 23.1521(d) requires minimum fuel grades in order for the engine to be operated within the limitations of § 23.1521, paragraphs (b) and (c). It is a general opinion that Jet A will be the fuel of choice. Fuel grade designations are applicable to aviation gasolines and, therefore, are not appropriate for aircraft diesel engines. The intent of the requirement is clear; however, the turbine engine "fuel designation" is more applicable for this section.

Fuel gelling or freezing has not been a concern with airplanes operating on gasoline fuels; however, kerosene fuels will freeze or gel at ambient temperatures much higher than gasoline fuels. The CRC fuel properties handbook shows the specification limit freezing point for Jet-A fuel as –40C, with the typical kinematic viscosity of 10 centistokes at the freezing point. An airplane operating on kerosene fuels should have some means of ensuring that the fuel in the tanks stays in the liquid state during operations. Fuel gelling or freezing is a special concern for small airplanes; smaller fuel tanks will cool much quicker than transport-sized fuel tanks.

The most common method of heating turbine fuel has been through motive fuel being returned into the fuel tanks. This method can often be shown to heat the fuel to an adequate temperature so that the danger of fuel freezing or gelling is avoided.

If the fuel in the tanks cannot be shown to flow suitably under all temperature conditions, then fuel temperature limitations will be required. For the different types of fuels (Kerosene (Jet) Fuel and Diesel car fuel), different temperature limitations may be necessary. If both fuels are used at the same time, the fuel temperature limit may be unclear. This is the case if the pilot does not know the type of the fuel; therefore, the worst limitation has to be used. Clear and unambiguous information will have to be in the Airplane Flight Manual (AFM). The temperature limitations would be considered as part of the essential operating parameters for an airplane with an engine that operates on kerosene-based fuels, and these limitations will be mandated as operating limitations on the TCDS and in the Airplane Flight Manual (AFM).

(1) The take-off temperature limitation will be determined by testing to determine the minimum cold-soaked temperature at which the airplane can operate.

(2) The minimum operating temperature limitation will be determined by testing to determine the minimum operating temperature acceptable after take off from the minimum take-off temperature established in (1).

Analysis should be avoided as testing is preferred in establishing these limitations, similar to hot fuel testing in an overall systems test. If low temperature operating limits are not established by testing, then the airplane will be temperature limited. The temperature limit is set by establishing the temperature where the specified fuel gels, by evaluating any limiting viscosity effects of the fuel at the cold temperatures, and by adding an appropriate temperature margin above any limiting temperature. The temperature margin will be necessary to account for the variations in fuel properties in order to allow adequate fuel flow at the limiting temperature. This requirement (depending upon how it is implemented) could also impose the need for a fuel temperature display.

Section 23.1521(e) will probably need to be replaced by a special condition requiring the establishment of maximum and minimum operating temperatures, as discussed above, for any airplane powered by a diesel engine.

§ 23.1557(c)(1)(ii) -- Miscellaneous Markings and Placards

The airplane will comply with the provisions of § 23.1557(c)(1)(ii) in lieu of § 23.1557(c)(1)(i). A special condition would most likely be needed to require these changes.

Inadvertent over-wing fueling with gasoline is also a possibility that should be minimized. An additional warning placard stating the following (or similar) should be placed nearby or integrated with the placard required by § 23.1557(c)(1)(ii), and the engine TCDS fuels should be listed:

EXAMPLE:

"WARNING
THIS AIRPLANE IS EQUIPPED WITH A
COMPRESSION IGNITION (DIESEL) ENGINE
SERVICE WITH APPROVED FUELS LISTED BELOW ONLY
JET A
JET A1
DIESEL #2"

A special condition will most likely be needed to require the placard.

Effect of Policy

The general policy stated in this document does not constitute a new regulation or create what the courts refer to as a "binding norm". The office that implements policy should follow this policy when applicable to the specific project. Whenever an applicant's proposed method of compliance is outside this established policy, it must be coordinated with the policy issuing office, e.g., through the issue paper process or equivalent.

Applicants should expect that the certificating officials will consider this information when making findings of compliance relevant to new certificate actions. Also, as with all advisory material, this policy statement identifies one means, but not the only means, of compliance.

Conclusion

The Small Airplane Directorate has determined that all proposed diesel engine installations, whether supplemental, amended or new TC projects, will be significant as defined in Order 8100.5. As such, the ACO is expected to notify the Standards Office of such projects promptly and forward certification project notifications and associated certification plans as soon as practical after project application. The ACO will identify the technological areas of concern identified in this policy paper, as well as any additional concerns and develop a G-1 issue paper to establish the certification basis. Signature authority for certificate issuance on these projects is retained by the Standards Office and will be redelegated on a case-by-case basis as this new technology is understood and integrated into aerospace products.

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for

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